

Model Editor Interface

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In Brief

Problem: The vast majority of the variation found in metrology data in semiconductor manufacturing is based upon systematic error sources. Systematic error sources are found and deconvolved best by data modeling. However, Overlay and Registration Models have changed little since the introduction of the step-and-repeat camera in the mid-1980's. While simulators have been the major focus for setup efforts in the recent past, data models have not maintained pace with advances in the optics and increases in process complexity.

Solution: New models are needed to properly handle process and step-and-scan error sources. User-customized models provide the optimal method of analysis development by providing the ability of each user to develop, test and maintain a library of proprietary models and calculation sequences.

Applications: Proprietary Models provide a unique opportunity to optimize exposure tool setup, control, and monitoring. Proven models can be employed in Advanced Process Control, process optimization, design validation and split lot performance evaluations.

Platform: The Vector Raptor Overlay Model Editor can be installed on any windows PC. The software develops and uses models associated with the Vector Raptor Overlay software from TEA Systems Corporation. Microsoft Excel® software is required.

Concept

Models of the systematic positional errors in the lithography sequence, derived from measurements of registration or overlay data, provide the most accurate tools for predicting error distributions in the process. An accurately quantified knowledge of the relative strength of each source of error and their interactions can then be used for process and tool setup as well as control and yield optimization. Extrapolations of modeled values to unmeasured areas of the field, wafer and lot result in estimations of the true error distribution that are significantly more accurate than classic methods that employ statistical calculations in their derivation.

Model Editor Interface

Models commonly used in the industry have changed little since the early introductions of step-and-repeat camera technology in the early 1980's. These classic models assume radial symmetry in both the wafer-process and field-exposure sequences ignoring the presence of bake plate or develop-cycle directional errors in the wafer distributions. Today's models also do not address the influence of the newer reticle-stage scan errors on the exposure field.

Vector raptor provides unprecedented flexibility combined with ease-of-use in customizing models for your unique process. Models can incorporate mixed Cartesian and Radial Coordinates in their descriptions as shown in the interface of Figure ME-1. Calculations are as simple as typing in the equation. Each coefficients equation is instantly tested for validity as soon as it is entered into the interface.

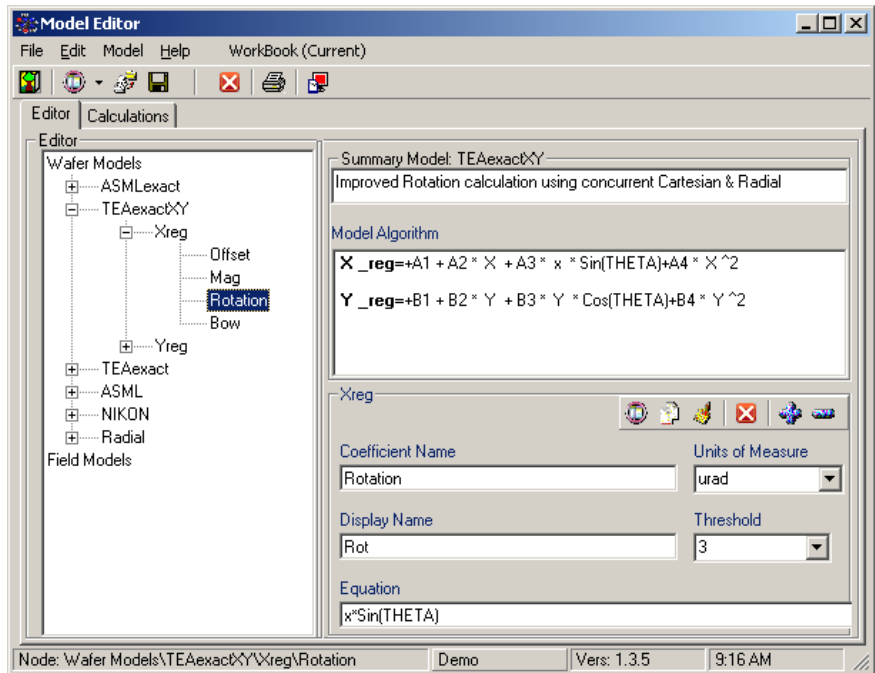


Figure ME-1: Vector Raptor Model Editor interface.

When fitted to a metrology dataset, each model adapts to the characteristics of the data and error populations currently present in the sample. Users can direct field models to address full-field responses in the classic method of modeling. Alternatively, each row and column of every field can be separately addressed by the algorithms to achieve unprecedented accuracy for advanced characterizations of the newest scanners and double patterning (DPL) applications. Fitted results obtained automatically minimize or eliminate the occurrence of overestimated analysis, singularities and even soft errors present in the metrology and the sparse-data samples often present during production. To the user this means that tool setup and process corrections can be made without the fear of under or over-correction or ringing in the control algorithms.

Vector Raptor Models are stored in Microsoft Excel® workbooks and can be directly edited in Excel or by using the graphical model editor as described in this chapter. Storage of the model libraries in convenient work format provides a mechanism for easy exchange and sharing of each user's best proprietary models through a simple exchange of the descriptor worksheets.

Model output displays are fully controlled by the user including the naming of coefficients, the algorithms used and the final units of display for each coefficient.

After fitting the model to the data, the application interface provides an easy evaluation of the impact of each coefficient. Coefficient contributions can be turned on or off in the dataset through a simple check-box in the model-coefficient listing. This method provides easy evaluation of the influence of each source-of-error by evaluation of either quantified data values or by visualization of the vector, contour and XY-plot graphics presented on the point-and-click interface.

The predictive benefits of coefficient, sub-model and model set investigations can be extrapolated to other sites on the field of wafer using the Vector Raptor Lot Correction and Simulation interfaces.

Model Libraries

Models are stored in two workbook based "Libraries". The "**WaferModels.xls**" library stores those models that can be applied to each wafer-based dataset. Similarly, the "**FieldModels.xls**" workbook stores the field-models for Vector Raptor. Each worksheet of the workbook stores one model description.

Model Libraries are stored in the "Models" subfolder of the Vector Raptor application. For software stored in the default installation folder, this path corresponds to:

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C:\Program Files\VectorRaptor\Models\WaferModels.xls

and

C:\Program Files\VectorRaptor\Models\FieldModels.xls

User's can easily determine the installation directory of their software by selecting "Help/About" menu option in the software.

The workbook for each library contains one worksheet for each model set. This workbook is re-loaded each time a data set is loaded into the interface. Changes made in the workbook between loads will therefore be included in the models the next time a data set is loaded.

Model Storage Format

Each model-worksheet follows the format shown in figure ME-2. Overlay model-sets typically contain two sub-models; one for the Xreg and one for the Yreg data. The polynomial description of each sub-model is fully specified by its coefficient list.

The "Xreg" sub-model of figure ME-2 is defined in rows 13 to 15 of column F and results in an equation of the form:

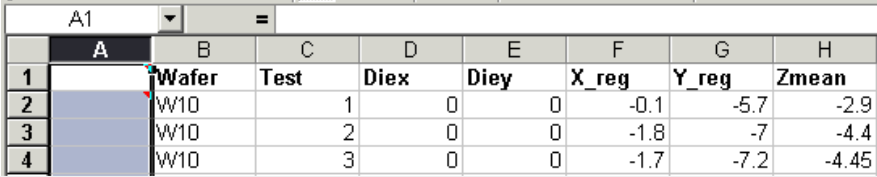
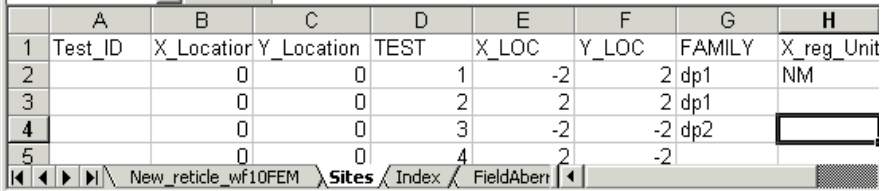
$$X_{reg} = A_1 * 1 + A_2 * X + A_3 * (-Y) + A_4 * Y^2$$

Model specifications follow the standard defined in the table:

	A	B	C	D	E	F
1	Name	ASML				
2	Models	2				
3	Date Created	05/04/2007				
4	Date Modified	05/04/2007				
5	Calculations	0				
6	Comments	0				
7	[Model]					
8	Name	Feature	Family	Coefficients		
9	Xreg		1 All	4		
10						
11	[Coefficients]					
12	NameCoef	DisplayName	Format	Units	Threshold	Equation
13	Offset		0.000			2 1
14	Magnification	Mag	0.0000	ppm		3 X
15	Rotation	Rot	0.000	urad		3 -Y
16	Bow		0.0000	nm/mm2		3 Y*2
17						
18	[Model]					
19	Name	Feature	Family	Coefficients		
20	Yreg		2 All	4		
21						
22	[Coefficients]					
23	NameCoef	DisplayName	Format	Units	Threshold	Equation
24	Offset		0.000			2 1
25	Magnification	Mag	0.0000	ppm		3 Y
26	Rotation	Rot	0.000	urad		3 X
27	Bow		0.0000	nm/mm2		3 X*2
28						

Figure ME-2: Worksheet in the WaferModels library specifying a model that is called "ASML"

Variable	Value	Comments
Name	String	String descriptor for this model set
Models	2	Number of sub-models within the model set. An overlay dataset will typically contain two models; one for X and one for Y overlay coefficients.
Date Created	String	Date format as "mm/dd/yyyy"
Date Modified	String	Date format as "mm/dd/yyyy"
Calculations	0	Not Currently implemented.
Comments	String	Any comment or note desired by the user
[Model]		Place holder for start of Model information. The following variable headers are placed along one row below that of the "[Model]" icon; row #9 of figure ME-2. The values for each variable are located on the next row and define the overall values for the feature sub-model.
Name	String	Name of the sub-Model
Feature	Integer	Value between 1 and 8. This value corresponds to the column of variable data to which the model will be fitted. Example: A value of "1" corresponds to the data variable located in

Variable	Value	Comments												
		<p>column "F" of a data set. A value of "2" corresponds to the variables in column G.</p> <p>This example assumes that the data table is in the Weir standard format and takes the general form:</p> 												
Family or String	"All"	<p>Corresponds to the site-family designator as specified in column "G" of the "Sites" worksheet of the Weir Standard Data Format. A value of "All" will apply the model to any site. In the sample sites sheet shown here, Sites 1, 2, & 3 are designated as families dp1 and dp2.</p> 												
Coefficients	Integer	The number of coefficients that will be included in the model. Also corresponds to the number of rows of descriptors in the next section of the model under the "[Coefficients]" moniker.												
[Coefficients]		<p>Placeholder for start of coefficient algorithm information.</p> <p>The following variable headers are placed along one row below that of the "[Coefficients]" icon; rows #12 to 16 of figure ME-2.</p> <p>The values for each variable are located on the subsequent rows; one row for each coefficient and define fitted equation for the sub-model.</p> <p>***** NOTE: The first Coefficient must always have a value of "1" for it's equation. This corresponds to the offset of the fitted equation for the submodel *****</p>												
NameCoef	String	Coefficient name that will be used during model variable storage.												
DisplayName	String	Coefficient name that will be displayed in graphs and reports. This may be a shortened or abbreviated form of the NameCoef variable.												
Format	String	<p>Fortran style string for formatting coefficient values. Examples:</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Format</th> <th>Displayed Format</th> </tr> </thead> <tbody> <tr> <td>6.34553</td> <td>0.00</td> <td>6.35</td> </tr> <tr> <td>6.34553</td> <td>0.0</td> <td>6.4</td> </tr> <tr> <td>6.34553</td> <td>SCIENTIFIC</td> <td>6.346E0</td> </tr> </tbody> </table>	Value	Format	Displayed Format	6.34553	0.00	6.35	6.34553	0.0	6.4	6.34553	SCIENTIFIC	6.346E0
Value	Format	Displayed Format												
6.34553	0.00	6.35												
6.34553	0.0	6.4												
6.34553	SCIENTIFIC	6.346E0												
Units	string	Units of measure for displayed variables. Coefficient values will be converted to these units before display. The available format may be typed in or selected from the interface. Sample values are shown in Appendix I of this document.												
Threshold	Integer	The number of observations (metrology points) that must be in the dependent data set to include this coefficient in the model. If a coefficient has a threshold of six (6), it will not be fitted to a data set with only five (5) data measurements.												

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Variable	Value	Comments
Equation	String	The equation portion of the coefficient. This equation may include any of the functions specified in Appendices II and III of this document. ***** NOTE: The first Coefficient must always have a value of “1” for it’s equation. This corresponds to the offset of the fitted equation for the sub-model ***

Accessing the VR Model Editor

The Vector Raptor model editor can be started using the following methods:

1. Select the “VR Model Editor” entry on the computer’s “Start Menu/Programs/TEA Vector Raptor” start menu.
2. Select the “Tools/Model Editor” menu item in the Vector Raptor interface.
3. Select the “Edit Individual Models” button on the Vector Raptor button bar.

The interface of figure ME-1 will become available.

Using Vector Raptor Models

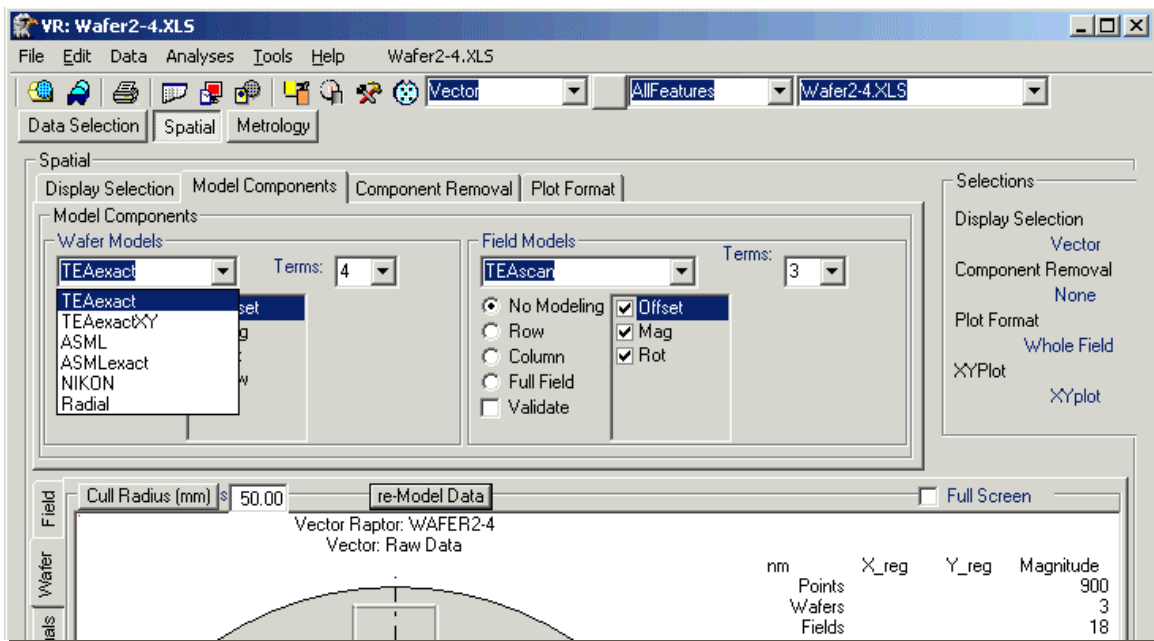


Figure ME-3: Model application interface for Vector Raptor

Models are used through the controls in the Vector Raptor – “Spatial” tab shown in Figure ME-3. The model-sets of the WaferModels.xls workbook are listed in the Wafer Models combo of the figure that is here shown in the drop-down state. One worksheet corresponds to each combo entry using the “Name” listing of the model-set.

To use a specific model, such as “TEAexact”, first select the model and then select the “Full Wafer” radio button to turn on wafer modeling.

- When a new model is selected, the coefficient check-box listings immediately under it will be updated. All coefficients will be fitted but the influence of each coefficient on the systematic components of the data will be shown only if the corresponding coefficient term for the model is check-marked.
- The “Terms” drop-down control is used to restrict the number of coefficient-terms of the model used in the data. This setting overrides the individual coefficient threshold settings described in the previous section of this chapter.
- Check the “Validate” box to turn on coefficient validation. Coefficient validation will set each coefficient’s value to zero (0) if twice the uncertainty of its determination is greater than the value of the coefficient. If a coefficient is set to zero, the values of the remaining coefficients are re-evaluated against the data to ensure proper fitting.

The FieldModels.xls library members are loaded into the Field-Models combo. These controls work similarly to the wafer model controls just described. The Field Model controls however present more options in the application of the model using the radio buttons as follows:

- “Row” – Fits the model to every row of every field of every wafer. The offset coefficients of these models therefore describe the locus of overlay error “travel” followed by the reticle scan stage during exposure. The higher order coefficients describe the changes in image size, size rotation as influenced by stage-travel vibrations and errors.
- “Column” – Fits the model to every column of every field of every wafer. The offset coefficients best describe the average lens-slit signature for the exposure. The higher order coefficients reflect the changes in image noise during exposure.
- “Full Field” – Classic fit of the sub-models to every field of every wafer.

Select one of the four tabs, “Wafer, Field, Field Residuals or Wafer Residuals”, located to the left of the display screen after a model has been selected to begin fitting of the model and a display of the results. The data will be remodeled only if the

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controls values are changed.. You can force a new model-fitting sequence by changing a control or by clicking the “re-Model Data” command button located at the top of the display screen.

The variable-combo control, located at the top-center of the interface shown in figure ME-3, should be set to “Vector” if the appropriate models are to be applied to both the X and Y overlay variables of the data. This control contains one listing for each variable column of the data. Changing the control to one of the variables other than “Vector”, such as “Xreg”, will result in the data for that variable being the only data column fitted to the model.

Model Outputs and Reports

Modeled coefficient values are displayed in the graph-screen below the controls if the statistics check-box, located under the “Display Selection” tab of this interface, is selected.

Wafer Models

Modeled coefficient values and their uncertainties are displayed on the “**WaferModel_Vector**” worksheet of the data workbook. Look in the “Index” worksheet for easy hyperlink access to these data sheets.

The name of this worksheet will change if both X & Y overlay vector components are not selected. Models can be applied selectively to only one variable by changing the values of the variable-combo located in the top-center of figure ME-3. If only the “Xreg” variable is selected, then the model results will be stored in the “**WaferModel_Xreg**” worksheet.

Alternatively, you can leave the variable-combo value at “Vector”, as shown in the figure, but display only the graphic and statistics for the Yreg variable by changing the “Plot Feature” combo setting also located on the “Display Selection” tab.

The modeled results are summarized in an analysis report that is stored on the “**WaferResponse_Vector**” worksheet. This report details all of the modeled selects including the level of data culling and the response of both fitted and residual values of the data. Results are summarized across multiple wafers as averaged values for each sub-model and feature family.

Metrology sets containing multiple-wafers of data will also create a pop-up interface that contains a library of graphics plots of Raw, Fitted and Residual wafer data sorted by wafer and feature family.

Field Models

The “**FieldAberrations**” worksheet details the fitted coefficient values and their standard error ($_{SE}$) of estimation for every fit location. In the case of a “Full-Field” application, this will correspond to one variable fit for each field. If *Row* or *Column* fitting is selected there will be one entry for each row of each field of each wafer in the selected data. Results are summarized by feature and family.

An additional worksheet report will be created if either the *Row* or *Column* model-application is selected. The name of this worksheet takes the form of “**FieldModel_Column_Summary_Vector**” for column applied models. This worksheet summarizes the **average** row or column fitted values for the data set for each row or column position in the field.

Results for the average value of all data for the full lot are displayed on the “**FieldModelSum_Column_Vector**” worksheet for column fitted models. These values also correspond to the displayed values of the graphics screen.

Similar to the wafer, the results of the fit and the conditions of data selection and culling are reported on the “**FieldResponse_Column_Vector**” worksheet for “Column” fitted data. Row or Full-Field fittings simply change the corresponding portion of the worksheet name.

In addition to the basic wafer or field based graphic and statistics, data fitting will create a pop-up window that automatically plots the fitted coefficients for each coefficient. Row and Column based fittings will create graphics that summarize data and coefficients according to the position on the fields respective row or column.

Using the Model Editor Interface

The VR Model Editor interface, once again shown in figure ME-4, provides a mouse-sensitive graphic alternative to direct editing of the model’s worksheet.

In this figure, the Field-models have been selected from the Editor’s model explorer. The “TEAscan” model-set has been selected for editing.

The Comments associated with the model are posted in the first field to the right of this explorer. The algorithmic format of this model-set is next assembled in the Model Algorithm field for each sub-model. This Algorithm summarizes the full polynomial of coefficients with one row for each sub-model. Coefficients are organized top-to-bottom in model explorer frame and from left-to-right in the Model Algorithm display.

The user then selected the “Xreg” sub-model and it’s “Rotation” coefficient for editing. The coefficient behavioral values and its associated equation are displayed in the fields located in the lower right frame of the interface.

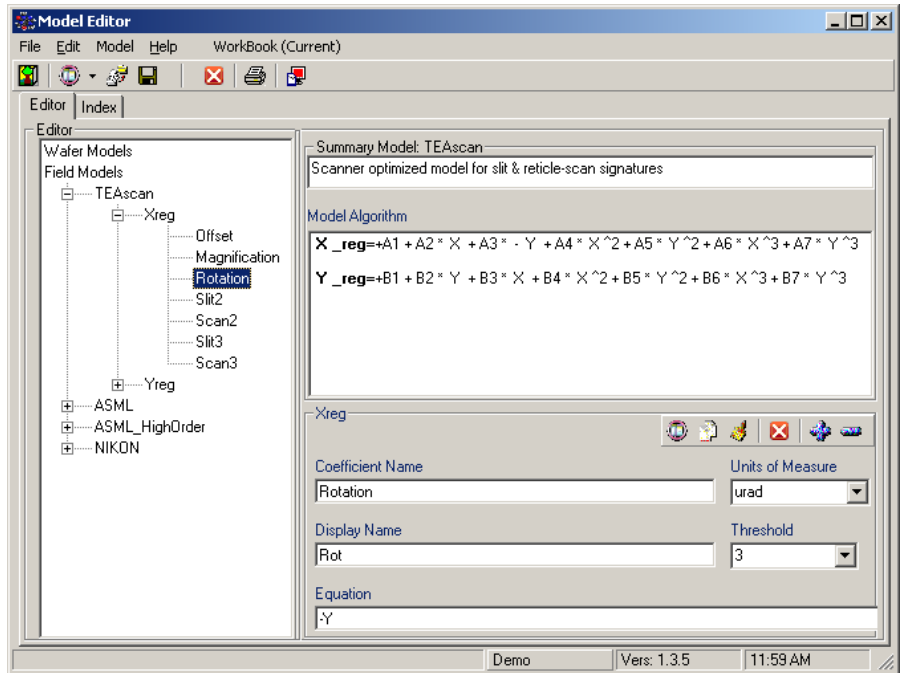


Figure ME-4: The Model Editor Graph Interface

The width of the Model Explorer window can be change by using the left mouse-button to drag the windows right-frame edge to the desired width.

Rules for Coefficient Definition

- Each coefficient set must start with a coefficient whose equation = “1”; this stores the coefficient offset or constant value
- A sub-model can consist of from 1 to 128 coefficients.
- Coefficients within a sub-model should contain unique names

Creating a New Model

A new model can be created by two methods.

- 1) Create a new wafer or field model from the wafer or field model template by using the “Model/New/New Wafer” or “Model/New/New Field” selection from the control menu or by selecting the button of the same name from the button bar, shown in figure ME-5.
 - a. The new model will request a model-set name to be entered.
 - b. The new model-set will contain both Xreg and Yreg sub-models.
 - c. Each sub-model will contain default coefficients for Offset, Mag, Rotation and Trapezoid.
- 2) Clone a new wafer or field model from an existing model by:

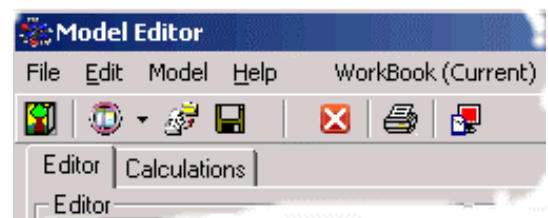


Figure ME-5: Menu and Button Bar

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- a. Use the mouse to select and display a model from either library.
- b. Select the “Model/Clone” menu command or the “Clone Current Model” button on the button bar
- c. A new model will be duplicated below the current entry. This new model will be named the same name as the selected model but with an added “_clone”. For example, if the “Nikon” model is selected and cloned. A new model will be entered in the structure with the name “Nikon_Clone”.

Deleting a Model

A model can be removed from the library by first selecting the model, and then by calling the “Model/Delete” menu or the Delete “X” button on the button-bar.

Renaming a Model

Select and then single click the name of a model. The highlighting on the model will refocus to the model name. You can now directly edit the name of the model. Right-click the model name to get a pop-up menu of cut/paste/delete options.

Coefficient Editor

Select a sub-mode to open the coefficients associated with it. Next select a coefficient name from the explorer to display the coefficient attributes within the Coefficient editor.

The coefficient editor contains fields for each coefficient attribute and a command button bar, shown in figure ME-6, in its upper right corner.

The format and function of each coefficient field attribute is described in the previous section of this document entitled “**Model Storage Format**”. Two data entry combo controls for the Units-of-Measure and Threshold values provide selections from the drop-down options. The user can either select from the options presented or directly type in any value.



Figure ME-6: Coefficient Editor Button Bar

The command buttons provided include:

- **New** command: when selected a coefficient will be created immediately above the currently selected entry with an equation value of ‘1’ and with the name “**NewCoef**”
- **Copy** command: copies the current coefficient values into the coefficient memory.
- **Paste** command: Highlight the location in the model that you want the copied coefficient to be located. The Paste command will enter the previously copied coefficient into the model immediately above the highlighted value. The new coefficient will be named the same name as the original copy with an added “_NEW” tag. For example, if the “BOW” coefficient is copied, when pasted back onto the sub-model, it will be named “Bow_New”.
 - Coefficients can be copied from one sub-model or model and then pasted into any other.
- **Delete** command: Deletes the currently highlighted coefficient.
- **Movement** command buttons: The “+” and “-“ buttons are used to move a coefficient up or down within the sub-model.

Appendix I: Standard Units of Measure

Base units-of-measure present in the Model-Editor's combo-control are given in the table shown below.

Units of measure may be also directly typed into the field of the control. For instance:

- (nm/CM) = Nanometers per Centimeter
- or (nm/mm^3) = Nanometers per Millimeter to the third power
- or (A/cm^5) = Angstroms per Centimeter to the fifth power

Abbreviations are not case sensitive.

Unit of Measure	Abbreviations
Angstroms	A,
Centigrade	C, c
Centimeters	Cm
DegPerSecond	Deg/sec
Degrees	Deg
Fahrenheit	F
Hours	H
KdegMinutes	
Meters	M or m
Microns	UM or um
Millimeters	MM or mm
MilliSeconds	MS or ms
Minutes	m
mj/cm2 (millijoules per cm squared)	
mw/cm2 (milliWatts per cm squared)	
Nanometers	NM, nm
Radians	RAD, rad
Seconds	S, Sec

Appendix II: General Functions for Calculations

The standard location variables for Vector Raptor Calculations are: X, Y, R and Theta.

R = Radius from the center of the wafer or field

Theta is the angle location of the point from its location on the Y-positive axis, clockwise positive.

Calculations are not case sensitive, so “ $X = r * \cos(\theta) = R * \text{COS}(\text{THETA})$ ”

Functions	Call Formula	Comment
(,)		Brackets such as (x+y)
+, -, *, /		Standard add, subtract, multiply and divide.
^	^	Raise to power, $X^3 == X$ cubed Ex: $Y = (3*X)^7$
%		Variable is treated as a Percentage value
Absolute	abs	Absolute value of ex: $\text{abs}(X+Y)$
E Constant	Naperian value	Constant = 2.718281828
Exponential	Exp, E, e	Naperian exponential “e” (the base of natural logarithms) raised to a power where e = 2.718282 (approximately). $X = e(7)$ $X = e^y$ $X = \text{exp}(y)$
Fix	Fix	Similar to “Int” If number is negative, returns the first negative integer greater than or equal to number
Integer	Int	Similar to “Fix” If number is negative, Int returns the first negative integer less than or equal to number
Logarithm base 10	Log10	Logarithm of a number to the 10 base. Ex: $X = \log_{10}(Y^2)$
Lograthrim	log	Natural logarithm of a number The natural logarithm is the logarithm to the base e. The <u>constant</u> e is approximately 2.718282. $\text{Log}_{10} = \text{Log}(X) / \text{Log}(10\#)$

Functions	Call Formula	Comment
Maximum	max	Return the maximum of a set of values contained in a specified set of variables. Ex: $x = \max(32,17,-33,28, \text{Alpha})$
Minimum	min	Return the minimum of a set of values contained in a specified set of variables . Ex: $x = \min(32,17,-33,28, \text{Alpha})$
Modulus	Mod	Used to divide two numbers and return only the remainder Ex: $A = 19 \text{ Mod } 6.7$ $A = 5$ MyResult = 10 Mod 5 ' Returns 0. MyResult = 10 Mod 3 ' Returns 1. MyResult = 12 Mod 4.3 ' Returns 0. MyResult = 12.6 Mod 5 ' Returns 3.
PI Constant	pi	$PI = \text{Atn}(1) * 4$ (by definition) Pi = constant = 3.14159265358979 (approximately) Ex: $x = \text{pi}$
Random	rnd	Random number based on seed. Seed entry is optional. Ex: $X = \text{rnd}(3.35)$ $X = \text{rnd}$
Sign	sgn	Returns the sign (+/- 1) of a number Ex: $x = \text{sgn}(-3.35) = -1$ $0 = \text{sgn}(0)$
Square Root	Sqr	Square Root of a number $x = \text{sqr}(32)$

Appendix III: Trigonometric Functions for Calculations

Trigonometric Functions	Call Formula	Comment
ArcCoSecant	arccosec	$Y = \text{arccosec}(x)$
ArcCosine	Arccos	Inverse cosine of a number $X = \text{arccos}(-0.3)$
ArcCoTangent	arccotan	$Y = \text{arccotan}(x)$
ArcSecant	arcsec	Inverse secant of a number $X = \text{arcsec}(-0.3)$
ArcSine	arcsin	Inverse sign of a number. $X = \text{arcsine}(-0.3)$
ArcTangent	Atn, atan, arctan	Ex: $y = \text{Atn}(\text{theta})$ or $y = \text{arctan}(3.2)$
Cosecant	Cosec	Returns the cosecant of a number = $1/\text{sine}$. Number may be in degrees or radians. $X = \text{cosec}(y)$
CoSine	cos	CoSine of an angle in radians. The result lies in the range -1 to 1. Ex: $\text{cos}(\text{theta})$
CoSine	cos	Ex: $\text{cos}(\text{theta})$
Cotangent	cotan	Returns the Cotangent of a number = $1/\text{Tangent}$. Number may be in degrees or radians. $X = \text{cotan}(y)$
Degrees	Deg	Converts Radians to degrees Ex: $X_{\text{deg}} = \text{deg}(X * 2.3)$
Hyperbolic ArcCoSecant	arccosech	$Y = \text{arccosech}(x)$
Hyperbolic ArcCoTangent	arccotanh	$Y = \text{arccotanh}(x)$
Hyperbolic CoSecant	cosech	$X = \text{cosech}(y)$
Hyperbolic Cosine	cosh	Ex: $X = \text{cosh}(3.2)$
Hyperbolic CoTangent	cotanh	$X = \text{cotanh}(y)$
Hyperbolic Inverse CoSine	arccosh	$Y = \text{arccosh}(x)$
Hyperbolic Inverse Secant	arcsech	$Y = \text{arcsech}(x)$
Hyperbolic Inverse Sine	arcsinh	$Y = \text{arcsinh}(x)$

Trigonometric Functions	Call Formula	Comment
Hyperbolic Inverse Tangent	arctanh	$Y = \text{arctanh}(x)$
Hyperbolic Secant	Sech	Ex: $X = \text{sech}(y)$
Hyperbolic Tangent	Tanh	Ex: $X = \text{tanh}(y)$
Radians	rad	Converts degrees to radians Ex: $X_{\text{rad}} = \text{rad}(y * 2.33)$
Secant	sec	Returns the Secant of a number = $1/\text{cosine}$. Number may be in degrees or radians. $X = \text{sec}(3.32)$
Sine	Sin	Sine of an angle in radians. The result lies in the range -1 to 1.
Tangent	tan	tangent of an angle in radians